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COMPACT ENVIRONMENTAL ANOMALY SENSOR (CEASE) FLIGHT INTEGRATION SUPPORT CONTRACT

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13. ABSTRACT *(Maximum 200 words)*

The outer space environment experienced by a modern, electronically sophisticated spacecraft can be very hostile due to interactions between its complex, sensitive electronics systems and the naturally occurring energetic particle population indiginous to the solar system. The Compact Environmental Anomaly System (CEASE) has been developed as a small, low-power device to monitor space "weather" and to provide autonomous warnings of conditions that may cause operational anomalies in the host spacecraft. CEASE uses a two-element, solid-state telescope and two radiation dosimeters to sample critical energetic particle fluxes and uses a sophisiticated real-time processing program that can forecast hazardous conditions before they affect the spacecraft. The spacecraft, in turn, can re-prioritize its operations, inhibit any anomaly sensitive operations such as attitude adjustments, or take any other prudent actions suggested by the potential for dangerous conditions.

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1. INTRODUCTION

The goal of the program is to support the environmental testing, calibration and spacecraft integration of the CEASE S/N 001 and S/N 002 instruments, built by Amptek, Inc. for Phillips Laboratory. This report contains the CEASE Engineering Mode data processing algorithms developed following the analysis of CEASE calibration data.

1.1 CEASE Telescope Data Format

The data collected from the CEASE telescope is stored in 80 channels, corresponding to different energy deposition values in the front (DFT) and back (DBT) telescope detectors. Each detector has eight energy deposition thresholds set in the readout electronics. Thresholds TFA through TFH are for DFT and TBA through TBH are for DBT. The positions of the threshold levels are shown as the solid grid lines on Figure 1. The thresholds separate the range of the possible energy depositions by incident particles into 80 regions called Logic Boxes (LB) shown in Figure 1 and labeled (m,n). The thick black curve shows the pattern of energy deposition in DFT and DBT by protons. The electron energy deposition pattern is more complex but, in most cases the electron energy deposition values would fall inside the rectangle which has LB (1,0) and LB (4,2) as its vertices.

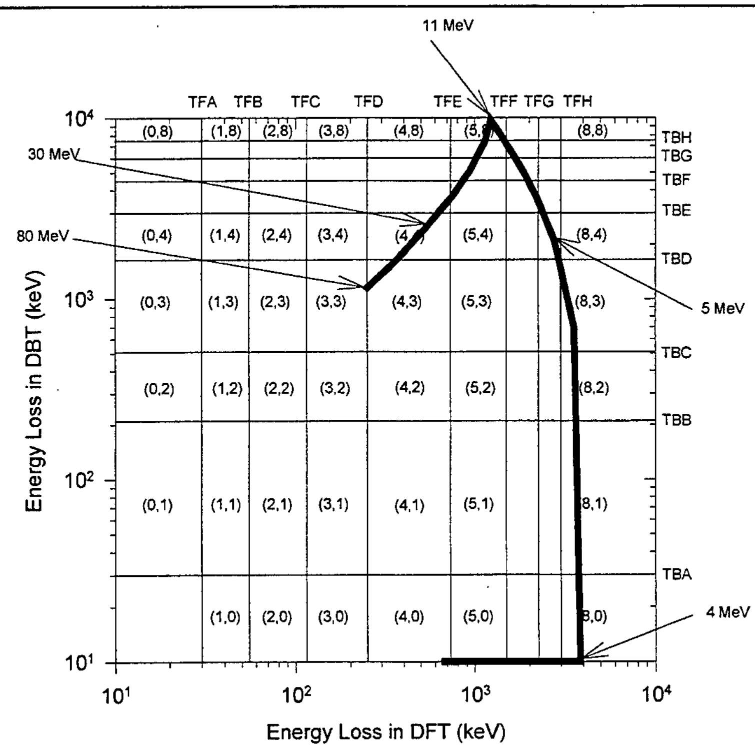

Figure 1. Telescope data Logic Boxes (LB).

Table 1. Listing of CEASE dead time correction parameters.

Meas. Count Rate (kHz)	True Count Rate (kHz)	Counts during 1 minute	Corr. Factor (C_τ)
17.6	22	1.06×10^6	1.25
32.0	56	1.92×10^6	1.75
36.0	81	2.16×10^6	2.25
36.4	101	2.18×10^6	2.75

1.2 CEASE Dosimeter Data Format

CEASE has two dosimeter detectors: DD1 and DD2. DD1 is located behind 0.08 in of Al shielding and DD2 is behind 0.25 in of Al shielding. Pulse heights from each dosimeter are stored in two 256 channel spectra. The LOLET spectrum covers the particle energy deposition range of 50 keV to 1 MeV and the HILET spectrum covers the range from 1 MeV to 10 MeV. The LOLET counts are due to electrons and high energy (E > 100 MeV) protons, while the HILET counts are due to lower energy protons.

2. DEAD TIME CORRECTIONS

CEASE analog electronics, for both the dosimeters and the telescope detectors have a 10 μsec event processing dead time, τ. The relationship between the true input count rate, N, and the measured count rate, M, is given by

$$M = N \exp\{-N\tau\}. \qquad (2.1)$$

Table 1 contains a list of some computed true and measured count rates and the resulting correction factor, C_τ, where

$$N = C_\tau M . \qquad (2.2)$$

In view of the values shown in Table 1, the following dead time corrections should be applied to the measured CEASE telescope and dosimeter count rates:

If $M < 17.6$ kHz	then $C_\tau = 1$
If $17.6 \leq M < 32.0$ kHz	then $C_\tau = 3/2$
If $32.0 \leq M < 36.0$ kHz	then $C_\tau = 2$
If $M \geq 36.0$ kHz	then $C_\tau = 3$

The count rate M is the total count rate for the given detector. The correction factor should be applied before any Status Register calculations are carried out.

3. RADIATION DOSE STATUS REGISTERS (SR1,2,3, AND 4)

CEASE units S/N 001 and S/N 002 each have two dosimeter detectors. DD1 is located behind 0.08 inches of Al shielding and DD2 behind 0.25 inches of Al shielding. Both dosimeters are 0.81 cm^2 in area and have a 500 μm thick depletion region.

By definition, the dose (in rads) delivered to a device is given by

$$D(rads) = 1.602 \cdot 10^{-8} \frac{\Delta E\,(MeV)}{M(g)} = 1.70 \cdot 10^{-7}\ \Delta E\,(MeV) \qquad (3.1)$$

where ΔE is the energy deposited in the device and M is the device mass (0.094 g for DD1 and DD2).

__Note:__ If a different size or different depletion depth detector is used for one of the dosimeters, the appropriate mass would have to be used in Eq. (3.1) and the numerical factor of 1.70 x 10^{-7} would change.

Each dosimeter has two 256 channel spectra, that correspond to events with either high gain or low gain activated. The pulse heights from high gain events, due to incident electrons and high (E > 100 MeV) protons, are stored in the LOLET spectrum and the pulse heights from low gain events (low energy protons) are stored in the HILET spectrum. The nominal calibration for the spectra are 4 keV/Channel = 0.004 MeV/Channel for the LOLET spectrum and 40 keV/Channel = 0.40 MeV/Channel for the HILET spectrum. Thus, a single dose count in a LOLET spectrum corresponds to 6.8 x 10^{-10} rads and to 6.8 x 10^{-9} rads in the HILET spectrum.

The incremental DD1 and DD2 LOLET and HILET flux counts (LL1C, LL2C, HL1C and HL2C) and dose counts (LL1D, LL2D, HL1D, HL2D) are computed for each 60 second Engineering Mode Interval. The DSP board memory, containing DD1 and DD2 data is read out j_{max} times every 60 seconds and the incremental flux and dose counts are given by

$$LL1C = \sum_{j=1}^{j_{max}} \left(\sum_{i=0}^{255} LL1S_i \right)_j \qquad (3.2)$$

$$LL2C = \sum_{j=1}^{j_{max}} \left(\sum_{i=0}^{255} LL2S_i \right)_j \qquad (3.3)$$

$$LL1D = \sum_{j=1}^{j_{max}} \left(\sum_{i=0}^{255} (i+1) LL1S_i \right)_j \qquad (3.4)$$

$$LL2D = \sum_{j=1}^{j_{max}} \left(\sum_{i=0}^{255} (i+1) LL1S_i \right)_j \qquad (3.5)$$

$$HL1C = \sum_{j=1}^{j_{max}} \left(\sum_{i=0}^{255} HL1S_i \right)_j \tag{3.6}$$

$$HL2C = \sum_{j=1}^{j_{max}} \left(\sum_{i=0}^{255} HL2S_i \right)_j \tag{3.7}$$

$$HL1D = \sum_{j=1}^{j_{max}} \left(\sum_{i=0}^{255} (i+1) HL1S_i \right)_j \tag{3.8}$$

$$HL2D = \sum_{j=1}^{j_{max}} \left(\sum_{i=0}^{255} (i+1) HL1S_i \right)_j \tag{3.9}$$

where $(LLnS)_j$ and $(HLnS)_j$ are the DDn LOLET and HILET 256 channel spectra for the j^{th} interval.

The minimum storage size requirements for LLnC and HLnC are 3 bytes. This permits a maximum counting rate of 1.7 x 10^7 counts / 60 seconds = 2.8 x 10^5 counts/sec. The minimum storage size requirements for LLnD and HLnD are 4 bytes. Thus, the maximum LOLET dose rate is 4.3 x 10^9 counts * 6.8 x 10^{-10} (rads/count) / 60 sec = 0.049 rads/sec = 175 rads/hr = 1.5 x 10^6 rads/yr. The maximum HILET dose rate is 10 times the LOLET dose rate.

The total doses, TD1 and TD2, are the cumulative sum of the incremental LOLET and HILET doses for each dosimeter.

$$TD1 = 2\sum_{n=1}^{N_{tot}} \left(C_{\tau n} \left(LL1D + 10 \cdot HL1D \right) \right)_n \tag{3.10}$$

$$TD2 = 2\sum_{n=1}^{N_{tot}} \left(C_{\tau n} \left(LL2D + 10 \cdot HL2D \right) \right)_n \tag{3.11}$$

where $C_{\tau n}$ is the n^{th} Engineering Mode Interval dead time correction, the factor 2 accounts for the fact that each dosimeter has a 50% duty cycle and the factor 10 accounts for the different gains of the LOLET and HILET spectra. N_{tot} is the total number of Engineering Mode Intervals (1 minute each) since the instrument was turned on. The TDn's are six byte registers, resulting in a maximum dose of 2.8 x 10^{14} counts * 6.8 x10^{-10} (rads/count) = 1.9 x 10^5 rads.

Notes:

1) TD1 and TD2 may not overflow, once the maximum capacity is reached, TD1 and TD2 may not be incremented.
2) $C_{\tau n}$ is to be computed using 2(LL1C + HL1C) or 2(LL2C + HL2C) as appropriate.

3.1 Low Shield Dose Status Register (SR1)

The LSD Status Register is computed using the equation

$$SR1 = 5\log_{10}\left(\frac{TD1}{B1}\right) \tag{3.12}$$

where B1 is the threshold dose and SR1 is truncated to an integer value. The LSD threshold dose is 187 rads which corresponds to 187 rads / 6.8 x 10^{-10} (rads/count) = 2.75 x 10^{11} counts = 2^{38} counts.

$$SR1 = 5\log_{10}\left(\frac{TD1}{2^{38}}\right) \tag{3.12a}$$

The total low shield dose corresponding to the 16 values of SR1 is listed in Table 2.

Table 2. SR1 Status Register Listing.

SR1	LSD (rads)	SR1	LSD (rads)
0	187	8	7,441
1	296	9	11,793
2	469	10	18,690
3	744	11	29,622
4	1,179	12	46,947
5	1,869	13	74,406
6	2,962	14	117,926
7	4,695	15	186,900

3.2 High Shield Dose Status Register (SR2)

The HSD Status Register is computed using the equation

$$SR2 = 5\log_{10}\left(\frac{TD2}{B2}\right) \tag{3.13}$$

where B2 is the threshold dose and SR2 is truncated to an integer value. The HSD threshold dose is 93.4 rads which corresponds to 93.4 rads / 6.8 x 10^{-10} (rads/count) = 1.37 x 10^{11} counts = 2^{37} counts.

$$SR2 = 5\log_{10}\left(\frac{TD2}{2^{37}}\right) \tag{3.13a}$$

The total low shield dose corresponding to the 16 values of SR2 is listed in Table 3.

Table 3. SR2 Status Register Listing.

SR2	LSD (rads)	SR2	LSD (rads)
0	93	8	3,718
1	148	9	5,893
2	235	10	9,340
3	372	11	14,803
4	589	12	23,461
5	934	13	37,183
6	1,480	14	58,931
7	2,346	15	93,400

3.3 Low Shield Dose Rate Status Register (SR3)

The LSR Status Register is computed using the equation

$$SR3 = 5\log_{10}\left(\frac{2C_\tau(LL1D + 10 \cdot HL1D)}{B3}\right) \tag{3.14}$$

where B3 is the threshold dose rate and SR3 is truncated to an integer value. C_τ is to be computed using LL1C + HL1C. The LSR threshold dose rate is 7.13 x 10^{-4} rads/min = 0.043 rads/hour = 377 rads/year. This value corresponds to 7.13 x 10^{-4} (rads/min) / 6.8 x 10^{-10} (rads/count)/ = 1.05 x 10^6 counts/min = 2^{20} counts/min.

$$SR3 = 5\log_{10}\left(\frac{2C_\tau(LL1D + 10 \cdot HL1D)}{2^{20}}\right) = 5\log_{10}\left(\frac{C_\tau(LL1D + 10 \cdot HL1D)}{2^{19}}\right) \tag{3.14a}$$

The total low shield dose rate corresponding to the 16 values of SR3 is listed in Table 4.

Table 4. SR3 Status Register Listing.

SR3	LSR (rads/hr)	LSR (rads/year)	SR3	LSR (rads/hr)	LSR (rads/year)
0	0.04	377	8	1.71	14,996
1	0.07	597	9	2.71	23,767
2	0.11	946	10	4.30	37,688
3	0.17	1,500	11	6.82	59,700
4	0.27	2,377	12	10.80	94,618
5	0.43	3,767	13	17.12	149,959
6	0.68	5,970	14	27.13	237,669
7	1.08	9,462	15	43.00	376,680

3.4 Heavy Shield Dose Rate Status Register (SR4)

The HSR Status Register is computed using the equation

$$SR4 \;=\; 5\log_{10}\left(\frac{2C_{\tau}(LL2D+10\cdot HL2D)}{B4}\right) \tag{3.15}$$

where B4 is the threshold dose rate and SR4 is truncated to an integer value. C_{τ} is to be computed using LL2C + HL2C. The HSR threshold dose rate is 7.13 x 10^{-4} rads/min = 0.043 rads/hour = 377 rads/year. This value corresponds to 7.13 x 10^{-4} (rads/min) / 6.8 x 10^{-10} (rads/count)/ = 1.05 x 10^{6} counts/min = 2^{20} counts/min.

$$SR4 = 5\log_{10}\left(\frac{2C_{\tau}(LL2D+10\cdot HL2D)}{2^{20}}\right) \;=\; 5\log_{10}\left(\frac{C_{\tau}(LL2D+10\cdot HL2D)}{2^{19}}\right) \tag{3.15a}$$

The total heavy shield dose rate corresponding to the 16 values of SR4 is listed in Table 5.

Table 5. SR4 Status Register Listing.

SR4	HSR (rads/hr)	HSR (rads/year)	SR4	HSR (rads/hr)	HSR (rads/year)
0	0.04	377	8	1.71	14,996
1	0.07	597	9	2.71	23,767
2	0.11	946	10	4.30	37,688
3	0.17	1,500	11	6.82	59,700
4	0.27	2,377	12	10.80	94,618
5	0.43	3,767	13	17.12	149,959
6	0.68	5,970	14	27.13	237,669
7	1.08	9,462	15	43.00	376,680

4. SOLAR CELL DAMAGE STATUS REGISTER (SR5)

The effect of ionizing radiation on solar cells is quantified, in engineering terms, with reference to "equivalent unidirectional fluence of 1 MeV electrons" (EF). Omni-directional particle flux, at any energy, can be converted to EF using an, empirically determined, damage factor DF(E,p). The value of DF depends both on the particle type, p, and its energy, E. For example, 45-50 MeV protons have DF = 2,100 while 1 MeV electrons have DF = 0.5 (note that the DF for the electrons is ½ and not 1 because the solar cells are assumed to be shielded from the back side). Typically, no significant degradation of solar cell power output is seen for EF fluences below 10^{14} electrons/cm^2 and significant degradation (> 50%) is seen for EF fluences greater than 10^{16} electrons/cm^2.

Damage factors depend on the cover glass thickness, since the glass shields the solar cell material from the lowest energy electrons and protons. The CEASE algorithm assumes a 6 mil (0.015 cm) thick cover glass. This is sufficient thickness to absorb protons with energies below 4 MeV and electrons with energies below 250 keV.

The CEASE algorithm will consist of selecting the telescope Logic Boxes (LB) which correspond to protons with E > 4 MeV and electrons with E > 250 keV and, after applying the appropriate geometric factors and damage factors, to sum them into a mission cumulative EF.

4.1 Protons

SR5 proton flux can be divided into two groups: 4 < E < 5 MeV and E > 5 MeV.

Group A: 4 < E < 5 MeV

LB_A: (7,1), (8,1), (7,2), (8,2), (7,3), (8,3), (6,4), (7,4) and (8,4)

Geometric Factor: $GF_A = 7.6 \times 10^{-4}$ cm^2-sr

Damage Factor: $DF_A = 2000$

Group B: E > 5 MeV

LB_B: (4,4), (5,4), (4,5), (5,5), (6,5), (7,5), (8,5),
(4,6), (5,6), (6,6), (7,6), (4,7), (5,7), (6,7),
(7,7), (4,8), (5,8), (6,8) and (7,8)

Geometric Factor: $GF_B = 7.6 \times 10^{-4}$ cm^2-sr

Damage Factor: $DF_B = 3000$

4.2 Electrons

SR5 electron flux consists of the Deep Dielectric Charging (DDC) LB's (see Section 7) and can be divided into three LB groups:

Group C:

LB_C: (4,0)

Damage Factor: $DF_C = 0.11$

Group D:

LB_D: (5,0)

Damage Factor: $DF_D = 0.30$

Group E:

LB_E: (1,1), (2,1), (3,1), (4,1), (1,2), (2,2), (3,2), (4,2), (1,3), (2,3), (3,3)

Damage Factor: $DF_E = 0.50$

The geometric factors for each of the LB's are complex, however, a detected electron with E > 250 keV has a nearly unity probability of ending up in one of the DDC LB's, so that a common DDC geometric factor of 1.6 x10^{-3} cm^2-sr can be assigned to the summed, damage factor corrected, counts from groups C, D and E.

4.3 Dead Time Correction

The dead time correction, C_τ, can be computed from the total telescope counts (over the past 1 minute long Engineering Mode Interval), TC

$$TC = \sum_{i=0}^{8}\sum_{j=0}^{8} LB_{ij} \tag{4.1}$$

where LB_{ij} is the 1 minute sum of the counts in the ijth Logic Box.

4.4 Equivalent Flux Computation

The omni-directional flux, f_i, is computed once per Engineering Mode Interval from

$$f_i = \frac{4\pi(sr)}{GF_i(cm^2 - sr)} \frac{1}{60\sec} C_\tau \cdot LBS_i \tag{4.2}$$

where i stands for one of the 5 groups (A through D) and LBS_i is the sum of the i^{th} group of Logic Boxes.

The equivalent 1 MeV electron flux for group i, ef_i, is given by

$$ef_i = DF_i \cdot f_i = \frac{4\pi(sr)}{GF_i(cm^2 - sr)} \frac{1}{60\sec} DF_i \cdot C_\tau \cdot LBS_i = G_i \cdot C_\tau \cdot LBS_i \tag{4.3}$$

The values of the parameter G for the various groups are shown below

Exact value: $G_A = 5.5 \times 10^5$ in algorithm use: $G_A = 5.5 \times 10^5 = 2^{19}$
Exact value: $G_B = 8.3 \times 10^5$ in algorithm use: $G_B = 1.0 \times 10^6 = 2^{20}$
Exact value: $G_C = 14.4$ in algorithm use: $G_C = 16 = 2^4$
Exact value: $G_D = 39.3$ in algorithm use: $G_D = 32 = 2^5$
Exact value: $G_E = 65.5$ in algorithm use: $G_E = 64 = 2^6$

4.5 SR5 Algorithm

The SUD Status Register (SR5) is computed using the equation

$$SR5 = 4 \log_{10}\left(\frac{EFT}{B5}\right) \tag{4.4}$$

where EFT is the mission-cumulative effective 1 MeV electron fluence (EF). EFT is computed in the following way.

1) Compute the incremental Engineering Mode Interval (1 minute) effective fluence (eft)

$$eft = \sum_i ef_i = C_\tau \sum_i G_i \; LBS_i \tag{4.5}$$

2) Divide eft by 2^{16} and add to previously stored total fluence value (EFT)

$$EFT = \frac{1}{2^{16}} \sum_{n=1}^{N_{tot}} eft_n \tag{4.6}$$

where N_{tot} is the number of Engineering Mode Intervals elapsed since CEASE was turned on.

3) Compute SR5

$$SR5 = 4 \log_{10}\left(\frac{EFT}{B5}\right) = 4 \log_{10}\left(\frac{EFT}{2^{28}}\right) \tag{4.7}$$

The factor B5 corresponds to an effective threshold fluence of $2^{16} \cdot 2^{28} = 2^{44} = 1.76 \times 10^{13}$ el/cm^2.

The effective fluence corresponding to the 16 values of SR5 is listed in Table 6.

Table 6. SR5 Status Register Listing.

SR5	EF (el/cm^2)	SR5	EF (el/cm^2)
0	1.8×10^{13}	8	1.8×10^{15}
1	3.1×10^{13}	9	3.1×10^{15}
2	5.6×10^{13}	10	5.6×10^{15}
3	9.9×10^{13}	11	9.9×10^{15}
4	1.8×10^{14}	12	1.8×10^{16}
5	3.1×10^{14}	13	3.1×10^{16}
6	5.6×10^{14}	14	5.6×10^{16}
7	9.9×10^{14}	15	9.9×10^{16}

5. SINGLE EVENT UPSET STATUS REGISTER (SR6)

The SEU Status Register (SR6) is a straight count of SEU-like events from DD3. In the event that the DD3 counter contains more than 15 counts, the SR6 value will be set to 15.

6. SURFACE DIELECTRIC CHARGING STATUS REGISTER (SR7)

Surface dielectric charging (SDC) is the charging of externally located spacecraft dielectric surfaces by low energy electrons. By definition, the electrons responsible for SDC have very short ranges in typical spacecraft materials. Therefore, the incident flux of interest in SDC is ½ of the omni-directional flux since the spacecraft body, or other instruments, will shield the "back" side of the surface.

The SDC Status Register (SR7) is a measure of the flux of low energy electrons ($40 < E < 250$ keV). The Status Register is computed from equation

$$SR7 = 3 \log_{10}\left(\frac{F_{SDC}}{B7}\right) \tag{6.1}$$

where F_{SDC} is the Engineering Mode Interval (1 minute) low energy electron flux and $B7 = 5.0 \times 10^4$ electrons/cm^2-sec is the threshold flux.

CEASE detects low energy electrons in Logic Boxes (1,0), (2,0) and (3,0). The geometric factors of these LB's are

LB (1,0): 5.3×10^{-4} cm^2-sr
LB (2,0): 11.3×10^{-4} cm^2-sr
LB (3,0): 14.3×10^{-4} cm^2-sr

The ratios of the (2,0) and (3,0) geometric factors to the (1,0) geometric factors are approximately 2 and 8/3.

The low energy electron flux (from one hemisphere) is given by

$$\begin{aligned} F_{SDC} &= \frac{2\pi(sr)}{5.3\cdot 10^{-4}\,(cm^2 - sr)}\frac{C_\tau}{60(\sec)}\left[LBS_{10} + \frac{1}{2}LBS_{20} + \frac{3}{8}LBS_{30}\right] \\ &= 198\ C_\tau\left[LBS_{10} + \frac{1}{2}LBS_{20} + \frac{3}{8}LBS_{30}\right] \qquad (6.2) \\ &= 198\ C_{SDC} \end{aligned}$$

where LBS_{no} is the summed 1 minute flux from LB_{no}, C_τ is the telescope dead time obtained from the telescope total counts TC, as computed using Eq. (4.1) and C_{SDC} is the product of the LB sum term in the brackets and the dead time correction term. If the telescope detector (DFT) lowest threshold is set to HIGH (no LB (1,0) counts) multiply C_{SDC} by 11/8. This factor compensates approximately for the SDC counts missed due to the high threshold. Combining Eq. (6.2)with the value of B7 = 5.0×10^4 electrons/cm^2-sec yields the complete formula for SR7

$$SR7 = 3\log_{10}\left(\frac{C_{SDC}}{256}\right) = 3\log_{10}\left(\frac{C_{SDC}}{2^8}\right) \qquad (6.3)$$

The effective fluence corresponding to the 16 values of SR7 is listed in Table 7.

Table 7. SR7 Status Register Listing.

SR7	EF (el/cm^2-sec)	SR7	EF (el/cm^2-sec)
0	5.0×10^4	8	2.3×10^7
1	1.1×10^5	9	5.0×10^7
2	2.3×10^5	10	1.1×10^8
3	5.0×10^5	11	2.3×10^8
4	1.1×10^6	12	5.0×10^8
5	2.3×10^6	13	1.1×10^9
6	5.0×10^6	14	2.3×10^9
7	1.1×10^7	15	5.0×10^9

7. DEEP DIELETRIC CHARGING STATUS REGISTER (SR8)

Deep dielectric charging (DDC) is the charging of shielded dielectric materials by penetrating electrons. By definition, the materials susceptible to DDC are not, in general, shielded by the spacecraft. Therefore, the flux of interest in determining SR8 is the omni-directional flux of high energy electrons (E > 250 keV).

The response of the telescope to high energy electrons does not vary significantly with energy and can be characterized by a single geometric factor of 1.6 x 10^{-3} cm^2-sr. While the energy response of individual Logic Boxes may be complex, the detected high energy electron must wind up in one of the DDC Logic Boxes. Thus, to obtain the DDC flux, we can sum the DDC logic boxes and apply a single geometric factor to the sum.

The DDC Status Register (SR8) is a measure of the flux of high energy electrons (E > 250 keV). The Status Register is computed from equation

$$SR8 = 3 \log_{10}\left(\frac{F_{DDC}}{B8}\right) \tag{7.1}$$

where F_{DDC} is the Engineering Mode Interval (1 minute) high energy electron flux and B8 = 4.2 x10^3 electrons/cm^2-sec is the threshold flux.

CEASE detects high energy electrons in Logic Boxes:

(4,0), (1,1), (2,1), (3,1), (4,1), (1,2), (2,2), (3,2), (4,2), (1,3), (2,3) and (3,3)

The high energy omni-directional electron flux is given by

$$\begin{aligned} F_{DDC} &= \frac{4\pi(sr)}{1.6\cdot 10^{-3}(cm^2 - sr)}\,\frac{C_\tau}{60(\text{sec})}\,LBS_{DDC} \\ &= 131\,C_\tau\,LBS_{DDC} = 131\,C_{DDC} \end{aligned} \tag{7.2}$$

where LBS_{DDC} is the summed 1 minute flux from the DDC Logic Boxes, C_τ is the telescope dead time obtained from the telescope total counts TC, as computed using Eq. (4.1) and C_{DDC} is the product of the LBS sum term and the dead time correction term. Combining Eq. (7.2) with the value of B8 = 4.2 x10^3 electrons/cm^2-sec yields the complete formula for SR8

$$SR8 = 3\log_{10}\left(\frac{C_{DDC}}{32}\right) = 3\log_{10}\left(\frac{C_{DDC}}{2^5}\right) \tag{7.3}$$

The effective fluence corresponding to the 16 values of SR8 is listed in Table 8.

Table 8. SR8 Status Register Listing.

SR8	EF (el/cm^2-sec)	SR8	EF (el/cm^2-sec)
0	4.2×10^3	8	1.9×10^6
1	9.0×10^3	9	4.2×10^6
2	1.9×10^4	10	9.0×10^6
3	4.2×10^4	11	1.9×10^7
4	9.0×10^4	12	4.2×10^7
5	1.9×10^5	13	9.0×10^7
6	4.2×10^5	14	1.9×10^8
7	9.0×10^5	15	4.2×10^8